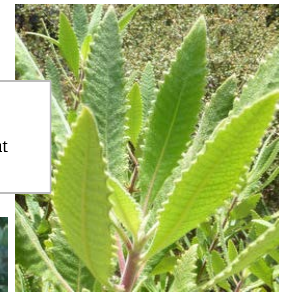
I. SPECIES	*Eriodictyon crassifolium* Benth.

NRCS CODE: (ERCR2)

Family: **Boraginaceae**
(formerly placed in Hydrophyllaceae)
Order: **Solanales**
Subclass: **Asteridae**
Class: **Magnoliopsida**

E. c. var. *crassifolium*,
W. Riverside Co.,



E. c. var. *nigrescens*,
Zoya Akulova, Creative Commons cc, cultivated at Tilden Park, Berkeley

E. c. var. *crassifolium*,
W. Riverside Co., A. Montalvo

A. Subspecific taxa **1. ERCRC** **2. ERCRN**	1. *E. crassifolium* var. *crassifolium* 2. *E. crassifolium* var. *nigrescens* Brand.
B. Synonyms	1. *Eriodictyon tomentosum* of various authors, not Benth.; *E. c.* subsp. *grayanum* Brand, in ENGLER, Pflanzenreich 59: I39. I9I3; *E. c.* var. *typica* Brand (Abrams & Smiley 1915). 2. *Eriodictyon crassifolium* Benth. var. *denudatum* Abrams
C. Common name	1. thickleaf yerba santa (also: thick-leaved yerba santa, felt-leaved yerba santa, and variations) (Painter 2016a). 2. bicolored yerba santa (also: thickleaf yerba santa) (Calflora 2016, Painter 2016b).
D. Taxonomic relationships	Plants are in the subfamily Hydrophylloideae of the Boraginaceae along with the genera *Phacelia, Hydrophyllum*, *Nemophila, Nama, Emmenanthe*, and *Eucrypta,* all of which are herbaceous and occur in the western US and California. The genus *Nama* has been identified as a close relative to *Eriodictyon* (Ferguson 1999). *Eriodictyon, Nama,* and *Turricula*, have recently been placed in the new family Namaceae (Luebert et al. 2016).
E. Related taxa in region	Hannan (2016) recognizes 10 species of *Eriodictyon* in California, six of which have subspecific taxa. All but two taxa have occurrences in southern California. Of the southern California taxa, the most similar taxon is *E. trichocalyx* var. *lanatum,* but it has narrow, lanceolate leaves with long wavy hairs; the hairs are sparser on the adaxial (upper) leaf surface than on either variety of *E. crassifolium*. *E. trichocalyx* is also the most closely related taxon based on DNA sequence data (Ferguson 1999).
E. Taxonomic issues	The name *E. crassifolium* and thetwo currently accepted varieties have had stable use in California since the treatment in Hickman (1993), but there are specimens from areas of southern California that are hard to place as one variety or the other. Munz (1974) recognized *E. c.* var. *nigrescens* but had not determined that *E. c.* var. *denudatum* was a synonym. However, he stated that *E. c.* var. *denudatum* was poorly defined and variable especially in the area from Fillmore to the Santa Ynez Mts. Abrams & Smiley (1915) described their var. *denudatum* as occuring in a zone of overlap between *E. trichocalyx, E. crassifolium,* and *E. californicum*. McMinn (1939) recognized var. *nigrescens* and var. *denudatum*, but said thickleaf yerba santa grades into these taxa in Ventura, Santa Barbara, and western Kern counties. Many taxonomists recognize Hydrophyllaceae as separate from the Boraginaceae (e.g., Hofmann et al. 2016), while others recognize the Namaceae (see I. D.).
F. Other	This species should be used judiciously in restoration or native plant landscaping because the plants can form large, spreading clones. *Eriodictyon* species have been used interchangeably in roadside restoration and erosion control with little consideration of which taxon actually occurs in the area. When making decisions about which taxon to plant, it is important to look at the natural range of the taxa being considered and to examine nearby, unplanted areas.

II ECOLOGICAL & EVOLUTIONARY CONSIDERATIONS FOR RESTORATION

A. Attribute summary list (based on referenced responses in full table)

Taxonomic stability - moderate
Longevity - long-lived, clonal
Parity - polycarpic
Flowering age - 2+ yr
Stress tolerance - moderate to high
Environmental tolerance - broad
Reproduction after fire - facultative seeder
Fragmentation history - historical and recent
Habitat fragmentation - high at low elevations
Distribution - intermediate, alluvial and slopes

Seeds - dormant, long lived
Seed dispersal distance - short
Pollen dispersal - intermediate to far
Breeding system - outcrossed
Population structure - unknown
Adaptive trait variation - unknown
Chromosome number - stable
Genetic marker polymorphism - unknown
Average total heterozygosity - unknown
Hybridization potential - low

SDM projected midcentury suitable habitat - var. *crassifolium* 81–92 % stable; var. *nigrescens:* 34–84 % stable.
SDM projected midcentury habitat gain - var. *crassifolium* : gain >> loss (assuming unlimited dispersal); var. *nigrescens* loss > gain (assuming unlimited dispersal) for all five models.

B. Implications for seed transfer (summary)

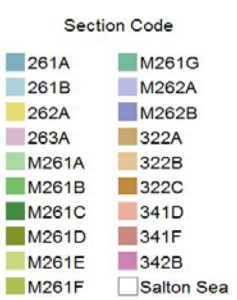
Both varieties occur most commonly within three major ecological sections and over 20 ecological subsections which suggests tolerances are broad, but also likely adaptive variation exists in these outcrossing plants. The plants are highly clonal, gene dispersal is limited and mainly by insect movement of pollen, which suggests seed collection for restoration should visit many stands in the same geographic area to ensure genetically diverse seed lots. Species distribution modeling of the southern California portion of taxon ranges indicates substantial differences between varieties in habitat suitability and projected future gain vs. loss in suitability (Section V). Varieties should be sourced to match recipient locations, including using the correct variety. Translocation outside a taxon's associated plant communities and currently predicted suitable habitat is not recommended.

III. GENERAL

A. Geographic range

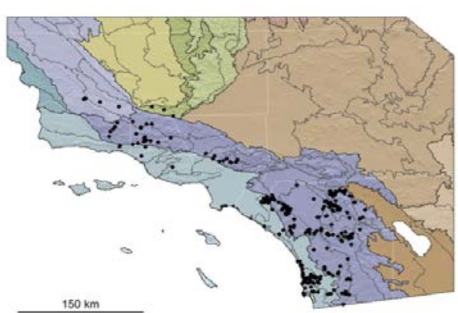
1. Primarily cismontane southern California, including the coast ranges and drainages, from eastern Santa Barbara Co. to northwestern Baja California (Abrams & Smiley 1915, Munz 1974; and data provided by the participants of the Consortium of California Herbaria (CCH 2016).
2. Primarily the Western Transverse Ranges of cismontane southern California from north eastern Santa Barbara Co. east to Los Angeles Co. and south into the South Coast Ranges. Scattered specimens are also recorded from the Peninsular Ranges further inland from Los Angeles Co. through San Diego Co. and from mountains that boarder the western Mojave Desert and (Munz 1974; and data provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/)). The Peninsular Range collections are hard to place into a variety (see I. E. Taxonomic issues and yellow occurrences under III. B.).

B. Distribution in California; Ecological Section and Subsection
(sensu Goudey & Smith 1994; Cleland et al. 2007)

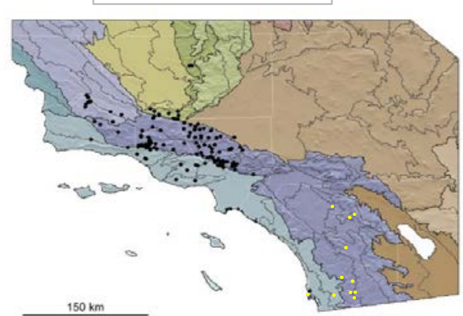


Map includes validated herbarium records (CCH 2016) as well as occurrence data from CalFlora (2016) and field surveys (Riordan et al. 2018). Legend has Ecological Sections; black lines are Subsections. Occurrences in yellow for *E. c.* var. *nigrescens* were not included in V. SDM, below.

E. c. var. *crassifolium*



E. c. var. *nigrescens*



1. *Eriodictyon crassifolium* var. *crassifolium*
Ecological Section/Subsection:
Sierra Nevada Foothills M261F: e (Tehachapi)
Central California Coast Ranges M262A: e,j
Southern California Coast 261B: b,e,f,i,j
Southern California Mountains and Valleys M262B: a-f, j-p
Colorado Desert 322C: a (bordering M262B)

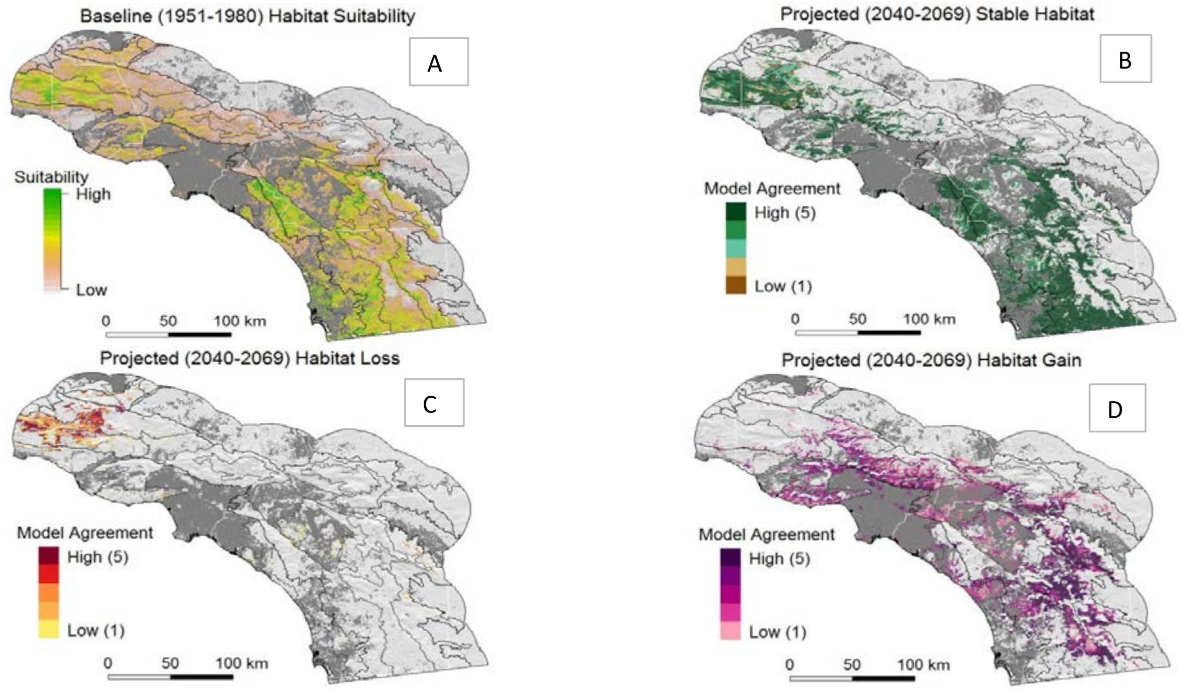
2. *Eriodictyon crassifolium* var. *nigrescens*
Ecological Section/Subsection:
Sierra Nevada Foothills M261F: d,e
Southern California Coast 261B: b,e,d,f,g (i,j unsure if native)
Southern California Mountains and Valleys M26B: a-e, (l,m,n,o data unsure)
Mojave Desert 322A: g,p (bordering M262B)

C. Life history, life form	Long-lived shrub, generally suffrutescent but woody at base, can form large, spreading clumps. Sawyer et al. (2009) note that plants may colonize from seed after fire and die out in 20 to 30 years.
D. Distinguishing traits	Suffrutescent, tomentose, rhizomatous shrub, 1 to 2 m tall, with large, thick, alternate leaves with distinct pinnate venation. The branched cymes produce many densely hairy, funnel-shaped, lavender flowers. The morphology of the trichomes and their density on the upper (adaxial) leaf surface separates the two current varieties (Hannan 1988). The varieties intergrade, but generally *E. c.* var. *crassifolium* has dense, usually villous hairs on both leaf surfaces, and the leaf surface lacks sticky glands. The leaves of *E. c.* var. *nigrescens* are notably less hairy with shorter hairs such that the leaf surface appears more green above than below (bi-colored); the leaves of var. *nigrescens* may also have some glandular hairs that make the leaf surface feel somewhat sticky.
E. Root system, rhizomes, stolons, etc.	Lateral spread of slender rhizomes of thickleaf yerba santa can be extensive. In an excavation study, Hellmers et al. (1955) documented spread of *E. c.* var. *nigrescens* to at least seven feet from center and reported that the rhizomes can travel much further. At the Riverside-Corona Resource Conservation District in Riverside (RCRCD), for a single plant of *E. c.* var. *crassifolium* installed in fall, two shoots from lateral rhizomes extended more than 10 feet from center by late summer; and for plants installed at a restoration site in December, multiple lateral shoots emerged from plants with some extending 3 to 10 feet from center by the second summer (A. Montalvo pers. obs.).
F. Rooting depth	In an excavation study, the roots of *E. c.* var. *nigrescens* were all within a foot of the surface of its gravely substrate (Hellmers et al. 1955). Others have reported adults of other Eriodictyon species to be deeply rooted (Ackerly 2004). Rooting depth may be variable.
IV. HABITAT	
A. Vegetation alliances, associations	Both varieties occur within alluvial scrub, chaparral, and woodland vegetation (Buck-Diaz et al. 2011, Hannan 2016). Sawyer et al. (2009) recognized the *Eriodictyon crassifolium* provisional shrubland alliance where it occurs with combinations of *Adenostoma fasciculatum, A. sparsifolium, Eriogonum fasciculatum, Rhus ovata, Rhus aromatica,* and *Salvia mellifera.* Thickleaf yerba santa occurs as a codominant within chapparal alliances including the *Adenostoma fasciculatum* alliance, especially in the *Adenostoma fasciculatum -Malosma laurina -Eriodictyon crassifolium* association, the *Ceanothus oliganthus* alliance, and *Ceanothus verrucosus* alliance. It also occurs as a codominant in the *Encelia farniosa* alliance and the *Lepidospartum squamatum* alliance.
B. Habitat affinity and breadth of habitat	Both varieties occur on slopes, mesas, river terraces, in washes, and alluvial deposits along rivers (Hannan 2016).  Stands of *E. c.* var. *crassifolium* are common on alluvial sites at the base of the Santa Ana and San Jacinto Mtns. Photo A. Montalvo, RCRCD.
C. Elevation range	1. Generally below 6,000 feet (Munz 1974). From 15-1520 m (Hannan 2016). 2. From 100 to 2440 m (Hannan 2016).
D. Soil: texture, chemicals, depth	Primarily on dry gravelly, rocky substrates (Munz 1974); soil shallow to moderately deep, well drained soils on slopes.
E. Precipitation	Both varieties occur primarily in the Mediterranean climate zone with cool to cold moist winters and warm to hot dry summers. Plants typically grow in areas with 10 to 40 in precipitation. For ecological sections occupied by *E. crassifolium* , annual normal precipitation ranges from 10 to 25 in (250 to 640 mm) in the Southern California Coast (261B), and 10 to 40 in (250 to 1020 mm) in the Southern California Mountains and Valleys (M262B), from 10 to 30 in (250 to 760 mm) in the Central California Coast Ranges (M262A), and 20 to 40 in (510 to 1020 mm) in the Sierra Nevada Foothills (M261F).
F. Drought tolerance	Drought tolerant.
G. Flooding or high water tolerance	Survives floods along streams, washes, where water evacuates quickly (Bendix 1998).
H. Wetland indicator status for California	None.

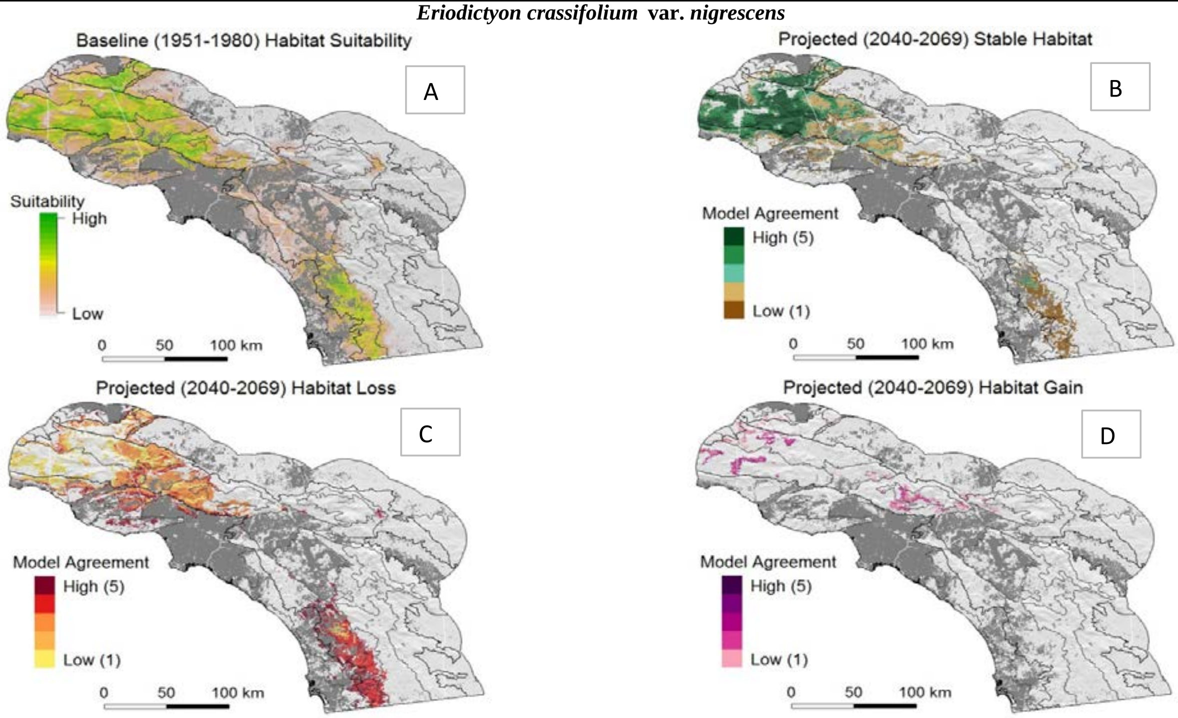
I. Shade tolerance	Full sun.

V. CLIMATE CHANGE AND PROJECTED FUTURE SUITABLE HABITAT

Eriodictyon crassifolium* var. *crassifolium



Eriodictyon crassifolium* var. *nigrescens



A. Species Distribution Models (SDM forecasts from Riordan et al. 2018) Map descriptions	Modeled habitat suitability under (A) baseline (1951–1980) and (B–D) projected midcentury (2040–2069) climate conditions. Projected future habitat suitability maps show agreement across five different climate model scenarios: (B) stable = suitable under both baseline and future conditions; (C) loss = suitable under baseline but unsuitable under future conditions; (D) gain = unsuitable under baseline and becoming suitable under future conditions. In all maps, land area that has already been converted to urban and agriculture land uses is masked in dark gray (FRAP 2015 Assessment; https://map.dfg.ca.gov/metadata/ds1327.html).

B. SDM summary	Species distribution modeling suggests that projected 21st century climate change could affect the two varieties of *E. crassifolium* differently. Assuming a future of continued high greenhouse gas emissions, Riordan et al. (2018) predicted 34–84 % of baseline suitable habitat for *E. c* var. *nigrescens* would remain suitable (stable) under mid-century conditions across future climate scenarios from five different general circulation models (GCMs) (V. A. Fig. B). Predicted gain in suitable habitat was negligible (1–9 % relative to baseline suitable habitat) and predicted suitable habitat loss greatly exceeded gain under all five climate scenarios (V. A. Figs. C-D). Interestingly, baseline suitable habitat was predicted for *E. c.* var. *nigrescens* in the interior mountains and valleys of San Diego County—an area thought to be outside of the range of variety *nigrescens* but within the range of variety *crassifolium*. Thus, some of the predicted suitable habitat loss for variety *nigrescens* in the Southern Granitic Foothills subsection of the Southern California Mountains and Valleys (M262Bn) was outside the current range of the taxon. In contrast, Riordan et al. 2018 predicted high stability of suitable habitat for *E. c.* var. *crassifolium* (81–92 %) under midcentury conditions. Predicted gain in suitable habitat (42–90 %) exceeded loss under all five climate scenarios. Loss in suitable habitat was predicted along the northwestern limit of the variety's range within the San Rafael - Topatopa Mtns. and the Northern Transverse Ranges subsections of the Southern California Mountains and Valleys (M262Ba and b, respectively). Principe et al. (2013) also predicted high habitat suitability and minor loss, but negligible suitability gain, for *E. c.* var. *crassifolium* in southern California under midcentury climate. Land use, altered fire regimes, and their interaction with climate change could negatively affect *E. crassifolium*. In southern California, human activity is the primary driver of fire (Keeley & Syphard 2016) with fire ignitions and fire frequency increasing with human population growth and the proximity of developed lands (Syphard et al. 2009). *E. crassifolium* is a suffrutescent subshrub able to regenerate from resprouting rhizomes or seed after fire (see VI. D. Regeneration after fire or other disturbance), but too-frequent fire may be detrimental for the species and is known to cause conversion of chaparral to annual grasses (Haidinger & Kelley 1993, Zedler et al. 1983). The high level of habitat conversion and fragmentation in lower elevations of the species' range may pose a considerable barrier to dispersal and gene flow that could negatively impact the adaptive capacity and ability of the species to respond to changing conditions. Riordan and Rundel (2014) caution that land use may compound projected climate-driven losses in suitable habitat in southern California shrublands.
C. SDM caveat (concerns)	The five general circulation models used to predict future habitat suitability assume a 'business-as-usual' scenario of high greenhouse gas emissions that tracks our current trajectory (Intergovernmental Panel on Climate Change, IPCC scenario RCP 8.5). They show how climate may change in southern California and highlight some of the uncertainty in these changes. The true conditions at mid-21st century, however, may not be encompassed in these five models. Predictions of current and future habitat suitability should be interpreted with caution and are best applied in concert with knowledge about the biology, ecology, and population dynamics/demographics of the species. They are best interpreted as estimates of exposure to projected climate change. Our models characterize habitat suitability with respect to climate and parent geology but do not include other factors, such as biotic interactions or disturbance regimes, that may also influence species distributions. Additionally, they do not include the adaptive capacity of a species, which will impact its sensitivity to changes in climate. See Riordan et al. (2018) for more information on SDM caveats.

VI. GROWTH, REPRODUCTION, AND DISPERSAL

A. Seedling emergence relevant to general ecology	The tiny and delicate seedlings (cotyledons about 1 mm long) emerge in the winter rainy season after fire (Went et al. 1952, Keeley et al. 2006), but they also emerge to a lesser extent in open habitat well after fire and in the absence of fire (J. Beyers pers. obs.). *Eriodyctyon californicum* seedlings also emerge in openings after disturbance (Ackerly 2004). Early seedling mortality is high but surviving seedlings grow rapidly. Plants in an outdoor nursery in Riverside, CA grew to about 30 dm tall within 10 months (A. Montalvo pers. obs.).
B. Growth pattern (phenology)	Plants actively grow and produce new leaves during the cool rainy season. New shoots from spreading rhizomes emerge in winter through mid spring. Plants tend to be densely leafy, sticky, and darker green during the growth phase. Plants from seeds take at least two and often three to four years to reach reproductive maturity. Flowering is in the mid to late spring, often peaking in late April to May, and fruits reach maturity in mid-summer (CCH 2016; A. Montalvo pers. obs.). During the hot dry season, some leaves drop and plants become more drab and grey. Leaves appear to turn over within a year similar to observations for *E. californicum* by Ackerly (2004).
C. Vegetative propagation	Shoots sprout from an extensive system of shallow rhizomes (Hellmers et al. 1955) which suggests plants can sprout from fragmented rhizomes.

D. Regeneration after fire or other disturbance	Plants recolonize sites from seed (Went et al. 1952, Vogl & Schorr 1972, Keeley et al. 2006) or from sprouting rhizomes after fire. Keeley et al. (2006) classify this suffrutescent species as a "facultative seeder", plants that recruit from both seedlings and sprouts after fire. In their study, a mean of 87% of plants resprouted and most seed germination occurred within the first two years following fire (data grouped for *E. trichocalyx* and *E. crassifolium*). Resprouting after moderate to low intensity fire is also know from the similar species *E. californicum* (Howard 1992). Fire stimulates seed germination. Laboratory trials showed that seeds stored in the soil are stimulated to germinate by exposure to heat and to the chemicals in smoke (Keeley et al. 2005). Bendix (1998) found *E. crassifolium* plant cover to be stable following flooding events. Plants of alluvial terraces along perennial streams and washes can also resprout from rhizomes after floods (A. Montalvo pers. obs.).
E. Pollination  *Bombus vosnesenskii* visiting *E. c.* var. *crassifolium* in Riverside County Photo by A. Montalvo.	Flowers are visited by a variety of animals including bees, hummingbirds, moths, beeflies, and butterflies (Moldenke & Neff 1974). Moldenke (1976) states that flowers in the genus *Eriodictyon* are pollinated primarily by bees in the genera *Bombus, Nomadopsis, Chelostoma, Anthophora,* and *Osmia* . Messinger & Griswold (2002) found that the related *E. tomentosum* attracted over 50 species of pollen collecting bees. Kremen et al. (2002) found 35 species of bees on *E. californica,* including species important to pollination of crops. *Bombus vosnesnskii* visits *E. crassifolium* (A. Montalvo pers. obs., see photo). Dobson (1993) found 23 species of bees on *E. californica.* The larger bees, such as *Bombus* and honey bees are known to forage over substantial distances of over 1,000 to 10,000 km, and several species of *Osmia* were found to forage over hundreds of meters (Zurbuchen et al. 2010). Declines in native bee and honey bee populations are of great concern (Murray et al. 2009). Habitat fragmentation from agriculture and urbanization have resulted in declines in pollinator populations and decreases in pollination services (e.g., Kremen et al 2002). In San Diego coastal sage scrub, Hung et al. (2015) found that nearby habitat fragments (each 5−80 ha and surrounded by urbanization) supported 14% fewer species of native bees than the larger reserve habitats (each > 500 ha). Habitat corridors are used by bees and are needed to help maintain bee and plant populations (Townsend & Levey 2005).
F. Seed dispersal	Seeds are primarily gravity dispersed (Hofmann et al. 2016). Tiny seeds shake out of erect capsules when windy or visited by animals (A. Montalvo, pers. obs.). Capsules are held about 2 m above the ground on springy branches, so when birds land on infructescences or when winds are gusty, we expect seeds may travel several meters. In areas that receive sheet flows or stream flows, seeds may be secondarily dispersed by water.
G. Breeding system, mating system	The rare *Eriodictyon capitatum* is thought to be self-incompatible (Elam 1994), requiring cross pollination for successful seed production. Self-incompatibility is expected in other perennial species of *Eriodictyon,* but flowers in the Hydrophyllaceae are often self-compatible (Hofmann et al. 2016). However, they generally have anthers that mature before stigmas become receptive (Hofmann et al. 2016), a mechanism that promotes cross-pollination. Further study is needed to determine if *Eriodictyon* is in general self-incompatible or if low seed set after self-pollination is caused by the deleterious effects of inbreeding acting during early embryo development.
H. Hybridization potential	Many of the generalist species of bees that visit *E. californica, E. tomentosa,* and *Eriodictyon* in general, are likely to visit more than one species of *Eriodictyon.* If populations overlap in flowering time and are in close proximity, cross-pollination is likely.
I. Inbreeding and outbreeding effects	Not studied. However, as in the rare *E. capitatum* (Elam 1994), seed production in populations that are made up largely of a few clones will likely be reduced from inbreeding effects.

VII. BIOLOGICAL INTERACTIONS

A. Competitiveness	Initially, the tiny seedlings are likely to suffer from competition with other plants, but within a year of emergence plants are likely to become good competitors. Once they are mature and capable of spreading laterally, they can become a dominant plant on the lower to middle alluvial terraces along major streams, and on slopes. The similar *E. californicum* which has low palatability increases rapidly at sites where surrounding more palatable plants are heavily grazed or browsed (Howard 1992).
B. Herbivory, seed predation, disease	Larvae and adults of the Chrysomelid beetle, *Trirhabda eriodictyonis,* feeds on the leaves of *E. crassifolium* and *E. trichocalyx* (Gould 2014, 2015).
C. Palatability, attractiveness to animals, response to grazing	Foliage is not likely to be palatable to many wildlife species, but if it is browsed, it can recover by resprouting from rhizomes. New sprouts of the closely related *E. californicum* are cropped by deer, but the species has very low value as browse for domestic livestock (Sampson & Jesperson 1963). *E. californicum* has been reviewed by FEIS.

D. Mycorrhizal? Nitrogen fixing nodules?	No studies found for any species of *Eriodictyon.* In a review of mycorrhizal associations, Brundrett (2009) stated that most taxa studied in the family Hydrophyllaceae have been non-mycorhrizal. In a review by Wang & Qiu (2006), most taxa of Boraginaceae (not including plants that were once classified as Hydrophyllaceae) have been reported as having arbuscular mycorrhizae.
VIII. ECOLOGICAL GENETICS	
A. Ploidy	Haploid count of n = 14 (Constance 1963)
B. Plasticity	No studies found.
C. Geographic variation (morphological and physiological traits)	Abrams & Smiley (1915) described a geographic pattern in the distribution of the densely tomentose forms (the *typica* form, now known as var. *crassifolium*) compared to less tomentose forms (the *nigrescens* form recognized as var. *nigrescens*) of *Eriodictyon crassifolium,* and the forms were thought to intergrade. No other studies of geographic variation in this species have been found.
D. Genetic variation and population structure	No studies found.
E. Phenotypic or genotypic variation in interactions with other organisms	No studies found.
F. Local adaptation	No studies found.
G. Translocation risks	No studies are available that assess the potential for adaptive differences among populations of either variety of *E. crassifolium* . There are also no studies that evaluate the crossing success of populations from different geographic origins within the species range.
IX. SEEDS	Rancho Santa Ana Botanic Garden Seed Program: view image of seeds of *E. c.* var. *c.* at http://www.hazmac.biz/050221/050221EriodictyonCrassifoliumCrassifolium.html 
A. General	Seeds are elliptic in shape, shallowly and transversely ridged, and 0.8 to 1.2 mm long (Wall & Mcdonald 2009).
B. Seed longevity	Seeds of many species of Hydrophyllaceae are long-lived in soil seed banks (Gamboa-de Buen & Orozco-Segovia 2008). Seeds are expected live many years under cool, dry storage (e.g., 42-47º F and 35−40% RH). At the Riverside-Corona Resource Conservation District, 3.25 year-old seeds germinated at higher rates after improved dormancy-breaking treatment than seeds a year younger (see IX. C. Seed dormancy). Seeds were collected in August 2011, cleaned, and stored indoors at ambient conditions three months, then stored in a cold room for two years (42−47ºF, and 32−47% RH), then buried for 10 months before smoke treatment (A. Montalvo pers. obs.).

C. Seed dormancy	Seeds of species that have been classified within the Hydrophyllaceae often have linear embryos that are underdeveloped at seed dispersal stage, complex cycles of dormancy and non-dormancy, and heterogeneity in germination response. Burial in soil may help to prime seeds for germination and those that follow fire tend to have seed coats that become permeable and able to germinate after exposure to smoke (Gamboa-deBuen & Orozco 2008). Seeds of the related *E. angustifolium* are linear and fully developed, but seeds are considered dwarf (Martin 1946 in Baskin & Baskin 1998). Such seeds often have morphological or morphophysiological dormancy for which embryos must continue to mature following seed dispersal and before they can germinate (Baskin & Baskin 1998). Light and heat may also play a role in germination of *E. crassifolium*. In early studies using lab-stored seeds collected in summer and treated the following winter and spring, Keeley (1987) found that 33% of untreated seeds of *E. crassifolium* germinated in light compared to only 2% in dark. In light, he found that germination increased after treatment with heat at 120°C for 5 min, after heating to 100°C for 5 min followed by treatment with liquid prepared from charred wood (charate), or by treating with charate alone (75%, 82%, 60%, respectively). In the dark, heat partially overcame the need for exposure to light (48%, 28%, 6%, same treatments respectively). Went et al. (1952) found that a 5 min. heat shock at 90ºC stimulated germination. In further studies, Keeley et al. (2005) found freshly collected control seeds had 0% germination, but treatment with a dilution of 1:100 liquid smoke:water (Wright's Concentrated Hickory Seasoning, B&G Foods, Inc.) resulted in significantly higher germination than in controls, seeds treated with more dilute liquid smoke (1:500 and 1:1000), or seeds exposed to heat shock. The effect of smoke and heat treatments increased significantly for seeds buried outdoors for one year prior to treatment. After burial, treatment of seeds with all three liquid smoke dilutions resulted in about 80% germination, a significant increase over the approximately 30% germination found in lab-stored seeds. After burial, heat shock exposure of 100°C for 5 min, and 110°C for 5 min also significantly increased germination over lab-stored controls, resulting in between 60% and 70% germination. At RCRCD, burial of seeds for 10 months before treatment with liquid smoke resulted in a twofold increase in emergence rate compared to use of liquid smoke alone the previous year (A. Montalvo pers. obs.).
D. Seed maturation	The tiny seeds mature during the early summer. A mixture of mature and immature capsules can be found into August. The seeds are mature when the dry capsules split open. There are about 4 brown to dark brown seeds per capsule.
E. Seed collecting and harvesting	Seeds are collected when the capsules are dry and begin to split open in July and August, depending on elevation and site conditions. The mature, fruiting inflorescences (infructescences) support many, whole capsules and may be cut and placed in open containers, paper bags, or fine-weave sacks. The capsules should be collected before the infructescences begin to turn downward to released seeds from the open capsules. The seeds are very tiny and can sift out of course-mesh sacks. These plants form large clones, more than 5 m wide, so collection distances should be from well-spaced patches more than 10 m apart to ensure sufficient genetic diversity in collections.
F. Seed processing	The tiny seeds need to be extracted from the hard, thick-walled capsules. This can be done by hand for small collections by threshing (rubbing) the capsules on a metal screen or sieve so that they break apart and release the seeds into a container below. The captured material is then winnowed or sieved through a series of smaller meshed screens. Wall & Mcdonald (2009) suggest rubbing over a small screen followed by sieving through #20 and #45 sieves. Seeds can be winnowed with a seed blower and resieved through a #18 sieve.
G. Seed storage	Store under cool, dry conditions. Cool, dry storage with controlled temperature and relative humidity may increase seed longevity.
H. Seed germination	Seeds germinate in open areas during the cool winter, rainy season and germination is higher after fire. For smoke-treated seeds planted in the fall in flats in an outdoor nursery in Riverside, CA, germination occurred in January and February. Seeds at colder, winter elevations are expected to emerge later in the season. Emerging cotyledons are very tiny (narrowly lanceolate, about 1 mm long); seedlings are difficult to see until they develop true leaves, which takes several weeks from the time of initial emergence (A. Montalvo pers. obs.). In southern CA, Keeley et al. (2006) detected seedlings of *E. crassifolium* and *E. trichocalyx* in post-fire monitoring plots at chaparral and coastal sage scrub sites during spring monitoring visits (the two species were lumped for analysis). Most seedlings emerged in the first two years following fall fires; 52% of seedlings were found in the first year, but 24%, 10%, 12% and 2% were found in the 2nd, 3rd, 4th, and 5th years, respectively.
I. Seeds/lb	Average of 154,000 pure live seeds/bulk lb and 500,000 seeds in a PLS lb (S&S Seeds (2017).
J. Planting	Seeds should be planted in the fall to take advantage of cool winter temperatures and rainfall.

K. Seed increase activities or potential

None known. Farming of this plant for seeds would not be practical because of the plant spreads many feet from where it is planted. The plant sends up sprouts from long, spreading rhizomes and resulting clones can be large in extent (see III. C. D.). Farming a sufficient number of genotypes for achieving good genetic diversity would be impractical unless clones can be kept small. Seeds are best collected from multiple wild stands.

X. USES

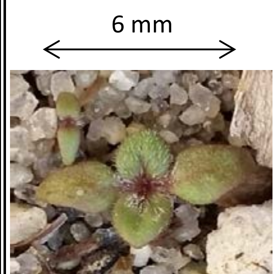
A. Revegetation and erosion control

Planted on road banks for erosion control in Riverside Co. (A. Montalvo, pers. obs.). Newton & Claassen (2003) report that seeds and container plants of *E. californica* are planted for erosion control and revegetation.

B. Habitat restoration

Plants grown from seeds are used in restoration of alluvial scrub vegetation by streams in western Riverside County in areas where it is a natural component of the vegetation (A. Montalvo, pers. obs.). Plants are also being used for restoration within chaparral vegetation in the Angeles National Forest. This taxon has have been planted in projects outside its natural range in areas where the *E. trichocalyx* is native in Riverside and San Bernardino Counties, likely owing to a lack of understanding of the natural ranges of these species, problems with identification, or both. In western Riverside County, plants installed in alluvial habitats in early winter have become fully established within one year with high survival rates (in the 80 percent range) with approximately weekly irrigation in the winter and spring during drought, tapering to occasional irrigation (approximately every two weeks) through the first summer (A. Montalvo and S. Pynn, pers. obs.).

C. Horticulture or agriculture



E. c. var. *crassifolium,* seedlings; upper left -- about two weeks after emergence; lower seedling with expanded cotyledons and first pair of true leaves . Seed source, W. Riverside Co. Photo: John Dvorak, RCRCD 2/4/2015.

Plants can be propagated from seeds or rhizome cuttings, but seeds will produce the highest genetic diversity unless cuttings are taken from many clones. Seeds must be treated to break seed dormancy before planting or treated immediately after planting by smoking flats with cool smoke, spraying with a liquid smoke product (e.g. Regen 2000 Smokemaster, Wright's Concentrated Hickory Seasoning- B&G Foods, Inc.), or sprinkling the surface with ground charred wood or vermiculite product infused with smoke. The treatment that produces the highest germination rate (upwards of 80%) involves seed burial outside for a year and then exposing the seeds to smoke (Keeley et al. 2005). Seeds should be sown thinly in seedling flats and covered only very lightly with coarse sand or seedling mix so that seeds are exposed to light. If not previously buried, it can take up to 2.5 months for seedlings to emerge.

The tiny seedlings grow relatively fast after the first true leaves appear. At an outdoor nursery in Riverside, seedlings that emerged in January grew to quart or 1-gallon size by early summer and roots filled 2-gallon pots by late fall. Seedling mix and potting soil must be well-drained. Once seedling plugs are shifted to larger pots, pots need to dry out between watering to avoid root-rot.

The related *E. californicum* has shown great promise as a hedgerow plant because it attracts many species of bees important to pollination of crops (Kremen et al. 2002).

E. c. var. *c.* in 1-gal pots after 10 months. A. Montalvo, RCRCD 9/5/2013.

D. Wildlife value

Primarily habitat structure and food for pollen and nectar feeding insects.

E. Plant material releases by NRCS and cooperators

None.

F. Ethnobotanical

The common name of the genus *Eriodictyon,* yerba santa, is Spanish for holy herb owing to the medicinal value of the plant (Timbrook 2007). This plant is listed as used by the Luiseño people for unspecified medicinal purposes (NAE 2016). Garcia & Adams (2009) (see also Adams & Garcia, 2005) report the Chumash used this plant to treat lung problems (asthma, tuberculosis, and bacterial pneumonia); to ease pain, roots were chewed or rubbed on skin. Leaves said to quickly stop bleeding and chewing leaves helps to keep the mouth moist. Plants contain many flavonoids; among them, eriodictyol might have antibacterial, anti-inflammatory, and expectorant properties. Bean & Saubel (1972) note similar uses by the Cahuilla, including for lung problems, bathing sore parts, and as component of a cough syrup. Anti-infective agents have been documented in *Eriodictyon angustifolium* (Dentali & Hoffmann 19912).

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XII. CITATION	Montalvo, A. M., E. C. Riordan, and J. L. Beyers. 2017. Plant Profile for *Eriodictyon crassifolium.* Native Plant Recommendations for Southern California Ecoregions. Riverside-Corona Resource Conservation District and U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Riverside, CA. Available online: https://www.rcrcd.org/plant-profiles
XIII. LINKS TO REVIEWED DATABASES & PLANT PROFILES	
Calflora	https://www.calflora.org/
Calscape	https://calscape.org/Eriodictyon-crassifolium-(Thickleaf-Yerba-Santa)?srchcr=sc5a35ccb7d848f
Fire Effects Information System (FEIS)	Only *E. californicum* is treated: https://www.feis-crs.org/feis/
Jepson Flora, Herbarium (Jepson Interchange)	https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?24670
Jepson eFlora (JepsonOnline, 2nd ed.)	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=24670
USDA PLANTS	https://plants.usda.gov/core/profile?symbol=ERCR2
Native Seed Network (NSN)	https://nativeseednetwork.org/
GRIN (provides links to many resources)	https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx
Native American Ethnobotany Database (NAE)	http://naeb.brit.org/uses/search/?string=Eriodictyon+crassifolium
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/050221/050221EriodictyonCrassifoliumCrassifolium.html
XIV. IMAGES	Image of *E. c.* var. *nigrescens* by Zoya Akulova has a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 license (CC BY-NC-SA 3.0, https://creativecommons.org/licenses/by-nc-sa/3.0/) and may be not used for commercial purposes. The image was cropped for use in this profile. Seed image by John Macdonald used with permission from Rancho Santa Ana Botanic Garden Seed Program (RSABG Seed Program), with rights reserved by RSABG; images may not be used for commercial purposes. Seedling image in X. C. by John Dvorak, RCRCD and images by Arlee Montalvo, RCRCD (both copyright 2017, RCRCD) rights reserved by the Riverside-Corona Resource Conservation District. All other images by Arlee Montalvo (copyright 2017). Photos may be used freely for non-commercial and not-for-profit use if credit is provided. All other uses require written permission of the authors and the Riverside-Corona Resource Conservation District.

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